

Lightweight Platforms for Managing Process Complexity

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Abstract. Managing engineering projects is becoming more complex especially when projects include networks of organizations. The complexity arises both from the growing number of relationships within a project as well as continual changes in project goals. The complexity impacts on process management as new ways are needed to manage the complex relationships and their continuing change. This paper proposes a systematic way to manage process complexity by developing the semantics to communicate within complex processes in meaningful ways. It then defines ways to implement these semantics in ways that allow users to create and change processes in terms natural to them. The paper considers the limitations of current collaborative technologies in supporting dynamic processes. The paper then describes the implementation on lightweight platforms and shows the application to supply chains, which many of which now require greater flexibility and collaboration.

Keywords: Collaboration, Knowledge Sharing, Process Management

INTRODUCTION

Increasing complexity within the current dynamic environment is calling for new ways to support the process of engineering system design and manufacturing processes. In particular it calls for communication and coordination needed to keep track of continuous change. This presents a challenge where there are numerous and changing relationships. Such coordination processes must pay more attention to system complexity now found in the increasingly dynamic business environment. Processes here change quite regularly. Communications must be provided to maintain awareness across large evolving systems. The communication is also needed to bring in the expertise needed to respond to change. Typical examples are in product design and its integration with manufacturing such as garment manufacture (Sen 2008) as customer preferences and manufacturing is rearranged. Another example is mold manufacturing (Ni 2007)

where there are incremental changes to mold forms from existing customers requiring continuous rearrangement of the manufacturing process.

Other examples are supply chains found in many industries as for example telecom (Berchet 2005, Heikkila 2002) or automotive (Howard 2006) industries. Here each partner is often one component of the workflow and is required to provide a service for the other partners. The services are negotiated between two partners at each interface. Alternatively negotiations can be collaborative and involve a number of businesses. In ERP systems developed in a stable environment, most negotiation takes place prior to the system being installed. In evolving environments constant adjustment is required with negotiation taking place during execution. (Rye 2008) for example calls for knowledge hubs to be established at all supply chain transitions in the mold industry to manage continual changes to mold forms. (Pralahad and Krishnan 2008) also argue that social networking will play an increasingly important role in such coordination. In many cases coordination is

through the exchange of knowledge, much of it of a tacit nature, created by process participants.

The paper provides systematic ways to describe processes in dynamic environments. It develops the semantics needed to describe complexity in meaningful ways and the development of systems that improve communication within a changing and complex environment. The paper defines the meaning of complexity and provides the semantics to define process requirements in complex environments and to convert the descriptions to computer support systems.

DESCRIBING SYSTEM COMPLEXITY IN A BUSINESS CONTEXT

The trends towards more dynamic systems (McAfee 2006) and continually changing relationships have a number of implications for the system designer. Figure 1 illustrates the emerging environment in its most abstract sense. It illustrates the greater emphasis on collaboration both within and between enterprises. The enterprise is now composed of a number of partners, suppliers and service providers. It is itself made up of many business units, which must themselves communicate as well as being assigned to liaise with other organizations. The impact on system engineering is that any product plan must now take into account an increasing number of stakeholders with continually changing requirements. Management of such arrangements requires the coordination and communication systems to maintain awareness across all stakeholders to make any system wide changes.

Complexity in such environments can be described in practical example or in generic terms. Practical examples include:

- The emergence of process ecosystems (Vigden, Wang, 2006), where links between the different processes are continually changing and there is need

to maintain awareness across processes and evaluating the impact of change in one process on other processes,

- The trend to a more service oriented environment where processes must continually respond to changes to customer needs or business partners preferences, and
- Greater client involvement in product and service design (Cova and Salle 2000). Here a typical business network is one where solutions are created through collaboration between supplier network and the customer network. Often there is a major supplier who originated a project and who then builds and coordinates a network of providers and customers to develop solutions that can provide continually evolving services and co-created services to customer

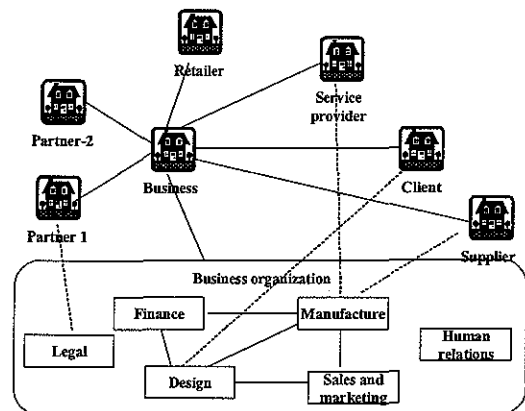


Figure 1 – The process ecosystem

The impact on process management and trends in system engineering

Dynamic systems require process management that goes beyond managing simple workflows and their material flows. On the other hand it requires systems that provide systematic ways to manage the kind of relationships shown in Figure 1. System managers must identify requirements of systems, and design ways to manage

processes within complex environments while operating in conditions of continual change. These requirements form part of the system engineering process.

This paper describes in an informal way what is meant by the term complexity and ways system designers deal with it. It then proposes that system engineers must consider a number of perspectives in system design. Using a number of perspectives can improve cognition within complex systems and ways to manage system change. The proposal here is to develop systems from a number of perspectives. These allow complexity to be managed in a systematic manner by taking perspectives in turn. It then describes modelling methods to describe systems from the different perspectives and the kinds of design processes needed to create such systems.

A GENERIC APPROACH BASED ON COMPLEXITY THEORY

The remainder of the paper proposes a systematic approach. It focuses on describing system change in a systematic and natural way and providing a number of perspectives to do so.

What is complexity?

To some people complexity is seen as arising from the interconnection on many objects. This view is combinatorial complexity. This can be the design of a complex communication systems or circuits as those found in modern day computer systems. Many of these can be solved by tools that deal with such complexity.

Another view of complexity comes from complexity theory. This deals more with coordinating multiple processes in ways acceptable to multiple stakeholders and their changing needs. Thus for example creating garment designs and finding the correct materials and manufacturer is complex in the sense that there is a large variety of choices that introduce uncertainty and require negotiation to create acceptable products. This continual change in

preferences calls for continual negotiation to implement the change. Similarly in mold manufacturing mold processes need to be adjusted as customer requirements change. Businesses are increasingly required to manage the complexity of such process. Coordination and collaboration become important in such management. Another important aspect is social structures as it is often people that need to make changes to systems.

Complexity theory (Holland 1995) provides a number of guidelines for the modeling design of complex adaptive systems (Kovacs 2004, Merali 2006). As such the paper draws on it to describe flexibility in workflow arrangements. The criteria here as applied to business activities include:

- The ability to self organize at local levels in response to a wide variety of external changes which implies changes to local supply chain operations to meet newly negotiated requirements,
- The ability to define and quickly establish self contained units that address well defined parts of the environment by adding more supply chain units to add expertise needed to provide new services in the chain,
- Loose coupling between system elements and a control system to reorganize the structure to respond to external change,
- The ability to organize connections between units and support the changed connections and interactivity to support variations in supply chain evolution,
- The aggregation of smaller units into larger components with consequent changes to the connectivity and interactivity,

Change is not just a mechanical process flow change but requires consideration from a number of perspectives, especially on how perspectives impact on each other.

System Perspectives

Process managers are increasingly required to design and manage processes. Design requires greater emphasis on social structures and knowledge with technology taking the role of supporting the social interactions. The perspectives proposed here include:

- The **business activities** and their actions and what they create,
- The **process workflow** or sequence of activities and the interdependence between activities,
- The **social structure** that describes roles and their responsibilities and the assignment of roles to individuals to describe the increasing importance of social interactions in any design.
- The **governance** or responsibilities within the system usually expressed in terms of roles,
- The **knowledge** created and used during the activities,
- The **organizational** perspective that defines organizational unit responsibilities and roles its staff will undertake. In relations between organizational units it includes the services it provides and value of these services., and
- The **technology** and how it can be adapted to the system.

These perspectives provide a cognitive structure for a systematic approach to create and change systems. For example a change in activity will be viewed in its effect on the social structure and knowledge requirements. The usual design approach is to develop models of systems from these different perspectives. The emerging environment is one where communication and knowledge will play an increasingly important role and

hence will needed to be considered in a more important and systematic manner.

Describing Change

Using perspectives allows change to be specified in a systematic manner by taking perspectives one at a time. For example, a change to the organization requires creation of new activities or changes to existing activities. Changes in an activity may require rearrangement of tasks within an activity or creation of new knowledge needed to satisfy an emerging need. Activity change can also include creation of a new team structure within an activity to take responsibility for the new knowledge need.

The question now is what are the specific concepts used in describing these perspectives and then define the technology infrastructure is needed to implement them.

DEFINING SUPPORT ALIGNED TO THE PROCESS

The common way used to develop semantics to describe processes is through conceptual models. Their purpose is to define the terms needed to describe systems in terms natural to users and then a way to convert models in these terms to computer systems. There are now a number of such models in practice mainly used to develop structured systems. This paper describes ways to model collaborative systems.

Perspective change	Effect on activity perspective	Effect on knowledge perspective	Effect on social perspective	Effect on technology perspective
Change organization to	Create new activities and link to existing activities	Define knowledge needed or created as a result of the change.	Identify new knowledge responsibilities in the activities and roles to take on the responsibilities	Identify any new workspaces for the activity.
Change to activity	Identify ways to realize the new responsibilities.	Define ways to realize any new knowledge requirements	Create any new roles and assign knowledge responsibilities to the new or existing roles	Add or delete workspace components and relationships between the components
Change to knowledge needs	Create or change activity tasks and roles to support any new knowledge needs	Define new interactions needed to manage the changed knowledge needs	Assign knowledge responsibilities to new or existing roles and change the collaborative architecture	Create Web 2.0 repositories and databases to support the business activity.
Change to social structure	Create new roles within the activity	Identify new knowledge requirements	Define responsibilities of new role. Map to collaborative architecture	Map roles and interactions to Web 2.0 technology

Table 1 – An organized way to change

Choosing the semantics to describe collaborative processes

Traditional methods include various project management tools, or modelling methods such as E-R or workflow modelling, which have been successful in developing structured systems in the past. These are increasingly found clumsy when modeling emergent processes found today. These need to include more perspectives than those found in structured systems. Especially important are ways to include the social and knowledge perspectives in design. The options for designers of such systems are:

- Using the traditional methodologies to model other perspectives,
- Extending existing methodologies with new perspectives either by providing new modelling techniques or extending current modelling structures, or

- Creating new methodologies.

This is particularly the case where communication is an important perspective. The difference and possible linkage in traditional and social is illustrated in Figure 2.

Figure 2 shows a model of arranging collaboration between two teams to meet client requirements. The ESN diagram is introduced in this paper as an extension of social networks. It includes the following concepts:

- Roles that define responsibilities. These responsibilities are shown by the attached text; for example, team members 'carry out assigned tasks',
- Participants who take on these roles shown by faces; for example Jane is the Project A team leader,

- Interactions shown by lines between the roles showing the kind of interactions between people assigned to these roles;

for example the two project leaders 'arrange distribution of some work'.

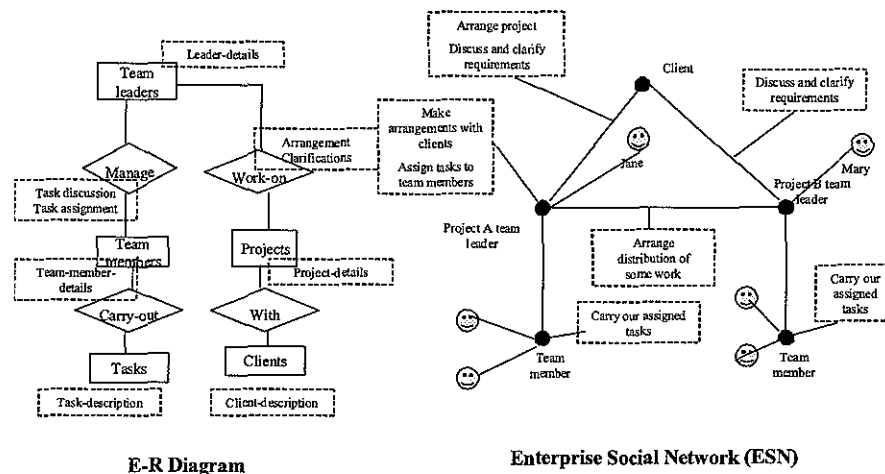


Figure 2 – Comparison of traditional modelling techniques and ESNs

In Figure 2, the E-R model models the same situation but now showing the responsibilities and interactions as attributes of entities and relationships. This primarily requires users to see the social perspective in terms of entities rather than a more natural way of people assigned roles with responsibilities as shown by the ESN in Figure 2. Hence a discussion may be let us take the role entity named client and define a relationship type with the clients projects managed by a team leader. Alternatively in the ESN we simply say set up an interaction between the client and Team Leader A.

An Alternate Model to Integrate the Perspectives

Figure 3 illustrates an alternate high level modeling method called the business activity model (BAM) that integrates the different perspectives. It includes concepts both from the business, social and knowledge perspectives. It is principally a high level diagram that shows the main entities in the system. It uses concepts of a conceptual model for collaborative systems

(Hawryszkiewicz, 2005). These focus on collaborative business systems and have been verified in earlier research (Hawryszkiewicz, 1996, 1997). As shown in Figure 3, the main modelling concepts are the activity (shown as clouded shapes), role (shown as black dots), participant (shown as faces), and artefact (shown as disk shapes). Figure 3 illustrates one instance of such model showing the main activities in a supply chain.

- There are alliance managers who set-up alliances and by creating joint plans for work flows across the enterprise,
- The alliance managers ensure that joint plans fit in with their production managers to define the capabilities to provide particular supply chain services and to create production plans.

E-R diagrams then suggest conversion to database models. They do not clearly express the dynamic nature of the relationships. There is no simple way to describe the conversion of the concepts to implementation.

Figure 3 has two advantages over the structured approaches as the E-R diagram as they combine the perspectives in a meaningful way. The second is that they provide a natural way to describe the

informal interactions and convert them to software other than structured systems, in particular, to social software.

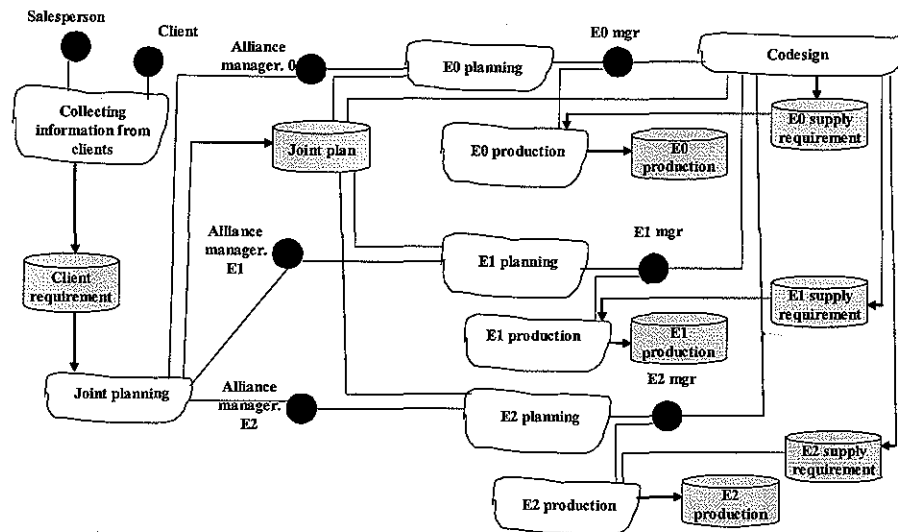


Figure 3 – Business Activities in the supply chain

Focusing on Knowledge and Social Perspectives

There is a further refinement that emphasizes social network and knowledge. Each organization has a manager and a production manager as well as an alliance manager. Figure 4 describes the social network in the system. Here each role is represented by a black circle. The lines between the circles model the interactions between the roles. The salesperson makes an initial contact with clients. The salesperson reports to the manager of Enterprise 0 as this is the enterprise that initiated the supply chain. The alliance manager of Enterprise 0 arranges and coordinates alliance discussions. These interactions form the basis for providing collaborative support technologies.

Specifying Change in Terms of Perspective Semantics

Change can now be specified in different perspectives and easily converted to implementation. The changes specified in Table 1 can be described in terms of the semantic concepts. For example:

- Change to the organization can be implemented by creating new business activities, then adding roles and interactions as needed,
- Changes to the activity can be described by changing its roles or artifacts,
- Changes to the role can be expressed by changes to role responsibilities and interactions.
- Assign a person to a role is expressed by linking a participant to a role.

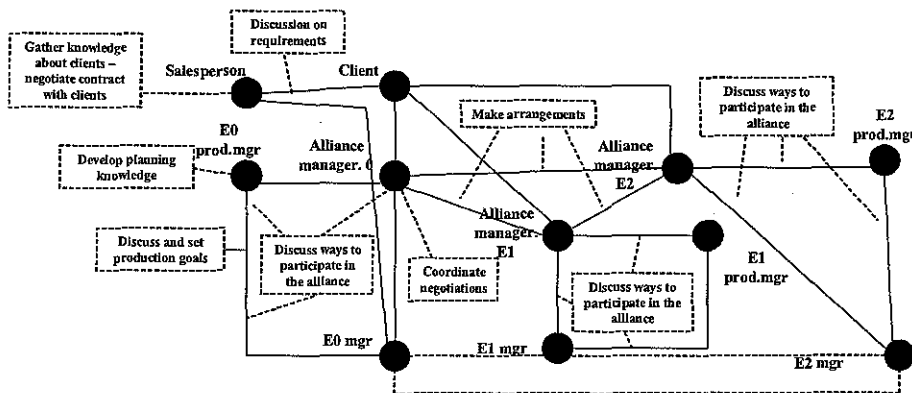


Figure 4 – Enterprise Social Network

The next requirement is for such models and their creation and change to be directly implemented using software.

DEFINING THE SUPPORTING TECHNOLOGY INFRASTRUCTURE

The two steps to be satisfied in creating a supporting infrastructure are finding the services to support the interactions, and place them in the workspace that support the realignment of such services to system changes.

Identifying required Services

Services must be chosen to support the interactions between the roles in the system. The main aspect of collaboration is to support the interactions between the different roles and provide services to support the collaboration. The choice is illustrated in Figure 5. The interactions in the ESN are now mapped to social software. For example a blog is provided for client discussions, whereas alliance discussions are supported by a WIKI.

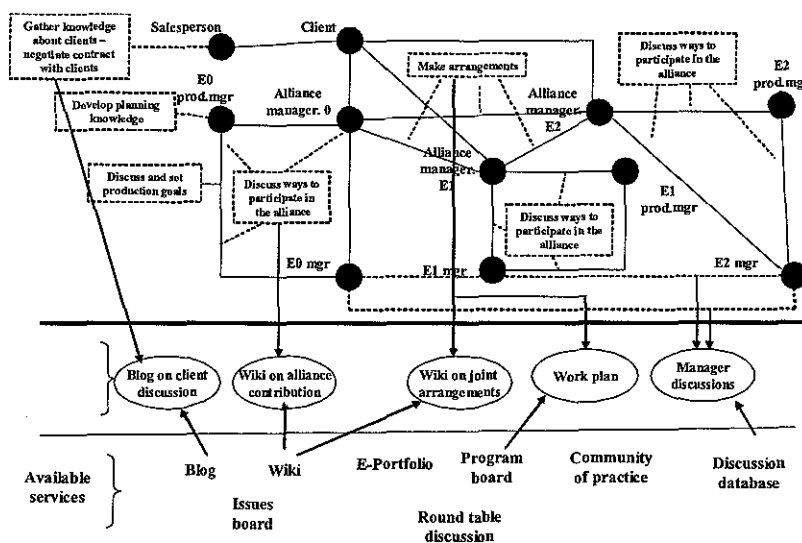


Figure 5 – Collaborative Infrastructure

Software Infrastructure Requirements

Most current systems are supported by workflow technologies that follow a predefined set of steps. Any required social networking is carried out outside such systems using a limited set of collaborative technologies. Knowledge sharing between the two is often minimal. Complex dynamic systems that align the collaborative interactions to formal processes are better supported by:

- **Middleware** - this provides a solution where workspaces can be customized to roles with links to corporate databases. They can be used to develop special interfaces for roles or activities. However middleware change is more difficult than change using lightweight technologies, and the expectation is that change would not happen frequently. In most cases it would require information technology specialists to construct an interface for each individual and change it as needed.
- **Lightweight technologies** - these provide better abilities for change but in many cases cannot easily connect to corporate wide databases or other lightweight systems. They can be used to develop the one-fits-one option or for mass personalization, which is ideal for knowledge workers. Many allow users themselves can create and manage their workspace.

Software must be chosen to support change specified in terms of natural semantics. Thus software must include commands that actually create a workspace, add a new role, setup a new interaction and place it in the context of the activity. Lightweight platforms are an important option. However to support user driven change they must provide users with commands based on the modeling concepts as a guideline. They

should include the concepts defined for the collaborative model while providing commands to easily create and change the structures of workspaces. Our experimental system, LiveNet, demonstrates the kind of support needed by workspace systems. Figure 6 shows the LiveNet interface and its typical commands.

It provides a menu that can be used to create new collaborative objects, including activities, roles, and artifacts. It also enables people to be assigned to the roles. Apart from these elementary operations the system includes ways to implement governance features as for example allowing roles limited abilities to documents. The system includes support for sharing artifacts across workspaces and a permissions structure to control such sharing. Social software such as blogs or discussion systems is supported and can be shared across workspaces.

Commercial systems in this area focus on middleware software that provides the commands that allows users to use the middleware functionality to create workspaces. Furthermore, it should allow users to change the workspaces as work practices change. Many manufacturers are now providing ways to integrate the kind of software with enterprise applications. A typical example here is Websphere provided by IBM. The challenge in many such systems is to provide ways to share knowledge across activities. They provide access to corporate databases but often do not support the sharing of knowledge collected in the course of knowledge work in identifying and solving problems, and making decisions.

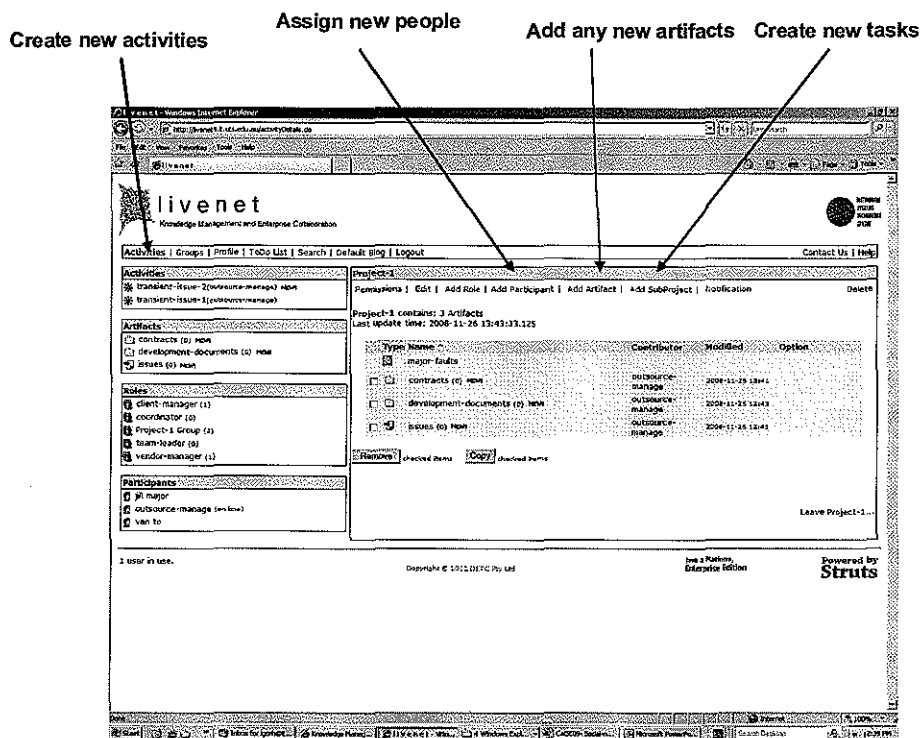


Figure 6 – A Demonstration Workspace

Specifying Change

Systems that support change must support the kinds of changes identified earlier in Tab11 and elaborated on in Section 3.5 in terms of modelling concepts. Software systems that present such semantics in natural ways can provide better support for user driven change. Lightweight technologies would need to support the commands. Again an illustration is given in Figure 7 where the menus provide commands such as creating new activities or roles or setting up new relationships and supporting them with technology matching the kind of interaction.

SUMMARY

The paper began by describing the increasing complexity of business processes and a systematic way to develop the

communication and coordination systems to support communication and coordination within such systems. It developed a generic model to define the kinds of interactions to be supported in the collaboration and used this as a guideline to define the kinds of technology infrastructure needed to align collaboration to the processes.

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